

Orthogonal Functions Based SAR Processing Algorithm  
for Processing Spaceborne Spotlight SAR Data

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Abstract

Spotlight SAR achieves an azimuth resolution much higher than the conventional strip mode SAR. Therefore, it provides a unique way to obtain high resolution images for some possible applications. The spaceborne spotlight SAR is still in its experimental stage such as that conducted during SIR-C (Shuttle imaging Radar C) flights. It is of great interest to process these data into imagery for investigation,

Previously reported spotlight SAR processing algorithms are based on the concept borrowed from the Computer Aided Tomography (CAT). Briefly, the values of each echo pulse post to range compression is viewed as the projections from one observation angle. Its Fourier pair represents one line of the entire image spectrum. By collecting all these spectral lines, one then convert the image spectrum from a polar grid into a Cartesian grid. The SAR image is obtained after a 2-D inverse FFT. This method was referred to as the direct Fourier method. Another method is to apply the convolution backprojection algorithm to this processing.

Although the direct Fourier method is much faster, but, it suffers from a degradation in the image quality due to the polar-to-Cartesian interpolation. The convolution backprojection is relatively better in image quality. But, the throughput rate is lower and yet does not achieve optimal image quality since a truncation to the convolution kernel cannot be avoided. In addition, the parallel beam CAT approach assumes that the iso-range lines within the radar footprint can be approximated by straight lines. This is however not true for a spaceborne SAR with a 1-band carrier or a lower frequency,

The algorithm proposed in this paper is based on the concept of orthogonal functions. It proves that the point target response of any point target within one resolution cell of a conventional SAR can be formulated as the superposition of several frequency modulation signals. In addition, these frequency modulation signals form an orthogonal function set. Therefore, one may use inner product method to reconstruct the SAR image. To speed up the processing, the fast Fourier correlation method can be applied where each convolution obtains one set of SAR image with along-track pixel spacing being proportional to the reciprocal of the PRF. After several image sets are obtained, one then interleave their image pixels to form the high resolution image.

The proposed convolution can be performed by a standard SAR processor software using the range migration interpolation algorithm. To improve the image quality, interpolators are designed to match to the 2-D spectrum of the point target response. The degradation of this kind interpolator is much less than that used in the direct Fourier method. in addition, this approach is as fast as the direct Fourier method.

The SIR-C spotlight data will be processed using all mentioned methods. Conclusions will be made based on the performance of these algorithms.

Preferred topic: SAR Data Processing Algorithms.

Preferred presentation style: lecture

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